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THE LIQUID STATE[1]

By Professor JOEL H. HILDEBRAND

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IN the selection of the subject of this address I was, of course, tempted to appeal to an audience, composed as it is mainly of those who are not physical chemists, by a strong seasoning from some such field as economics or political science or philosophy, which all of us feel competent to discuss. I resisted this temptation, however, except in so far as the words of my title itself, "The Liquid State," may have served as a lure for some of you by suggesting a treatise on corporation finance or the wetness of the post-prohibition era. I must now confess that any such implication was a deception; that my topic has to do with physical chemistry and that the only subsidiary implications I hope for are that my exposition may not prove too dry and that I shall be able to strike a happy mean between too much solid matter for a general audience, on the one hand, and a too gaseous attenuation for a scientific association, on the other.

I feel so bold as to count on a general interest in the topic itself because so large a proportion of natural phenomena occur in the liquid state. Any illumination I may be able to shed is likely to be helpful to workers in a number of fields other than chemistry. Moreover, all who are here can be assumed to possess that lively curiosity about natural phenomena which will guarantee an interest in a discussion involving so fundamental a subject as the nature and strength of intermolecular forces.

[1] Address by the retiring president of the Pacific Division, delivered on June 18 before a general session of the American Association for the Advancement of Science, Berkeley, California.

Allow me to illustrate the general problem in very concrete form by a photograph of a cylinder containing five distinct liquid layers, composed of hexane, aniline, water, phosphorus and mercury. If I had enough gallium I could show six layers. This is a stable system; if the cylinder is shaken, the layers will again separate. We are familiar with the fact that oil and water do not mix, but is it not astonishing that five liquids can be found, each of which furnishes so hostile an environment to the molecules of the other four that they remain largely segregated? This might almost serve as a model for present-day nationalism and my topic might have been stated for the benefit of any social scientist present as "molecular sociology."

I shall now attempt to lay a basis for understanding such a phenomenon. The physical differences between solids, liquids and gases are familiar to all. The kinetic picture of these differences can be stated in very elementary terms. In the solid, the molecules are held in a rigid lattice, each oscillating about its mean position. As the temperature rises, this oscillation increases until, at the melting point, the molecules no longer return to their former domains and the lattice breaks down. From this point on the molecular motion is no longer chiefly oscillatory in character, but the molecules are free to wander about the liquid, confined within the surface by the intermolecular attractions which are so strong that only an occasional molecule is bumped so hard by its neighbors as to be able to escape into the vapor state, where it moves between collisions with other molecules in rectilinear paths, which may be hundreds or even thousands of times greater than its own diameter. I will show this molecular agitation in the liquid state by a motion picture of the Brownian movement. It is evident that the solid state, in which the molecules are oscillating about fixed positions, and the dilute gas, in which they are moving most of the time in straight lines, present simpler theoretical pictures than the liquid state, in which their motions are far more irregular. It is not strange, therefore, that our knowledge of this state has lagged so far behind that of the other two.

As the temperature increases, the number of molecules possessing sufficient velocity to remain in the gaseous form increases; moreover, they hit the walls harder and oftener, with the effect of a rapidly increasing vapor pressure. When this becomes equal to the external atmospheric pressure, bubbles of vapor can form within the liquid; it boils and changes entirely to the gaseous state as heat is absorbed. The ordinary range of the liquid state thus lies between the melting and boiling temperatures. This range can, however, be extended by applying higher pressure. The liquid expands with increasing temperature and the vapor becomes more concentrated, until at last, at a temperature called the critical temperature, they become identical.

I will show this phenomenon in a sealed tube containing carbon dioxide. You will see how the surface separating the liquid from the gas flattens, becomes less distinct with rising temperature and finally disappears, to appear suddenly on cooling again to the critical temperature.

The intermediate character of the liquid state between solid and gaseous states is indicated in Table 1 of the molal heat capacities at constant volume of the three forms for argon, taken from Eucken.

TABLE 1

State	T	C_v
Solid	78	5.66
Liquid	88	5.54
"	124	5.10
"	140	4.65
Gas	90	3.01

The ranges through which different substances remain in the liquid state between the melting and boiling points vary enormously, as illustrated by the following figures in degrees centigrade: argon 3, nitrogen 14, mercury 371, gallium 2700, anthracene 124, phenanthrene 240.

In the last two cases, anthracene and phenanthrene, a mere difference of arrangement of the same atoms within the molecule causes a doubling of the liquid range. What are the causes of such differences as these? The answer has to do with the kind and strength of the intermolecular forces.

It has long been known to physical chemists that liquids may be divided into two classes, separated, it is true, as with most of our classifications, for example, that between bright and dull students, by a rather hazy boundary. One group obeys certain simple rules for the properties dependent upon intermolecular forces and are called "normal liquids." It includes such substances as benzene, the tetrachlorides of carbon, tin and silicon, carbon disulfide, the paraffin hydrocarbons, the liquid non-metallic elements, including iodine, sulfur, phosphorus, nitrogen, argon, chlorine and bromine. The other group of liquids is like "abnormal" children—they do not obey our simple rules, and their behavior is harder to predict. The direction of misbehavior usually suggests an enhanced attraction for each other; hence they have usually been called "associated" liquids. Like many abnormal children they are often more interesting than the normal ones. I have only to men-

tion water, alcohol, ether or ethyl butyric ester to indicate to you by your own emotional response that these liquids are rather more interesting than the others.

Table 2 is designed to illustrate several of the most striking regularities of the first group in contrast to the irregularities of the second. $\triangle S$ denotes the entropy of vaporization at constant volume, $d(\gamma v^{2/3})/dt$ is the temperature coefficient of molecular surface energy, ϵ is the dielectric constant and μ is the electric dipole moment. Please do not worry too much about the meaning of these figures, as that is not the point. I will explain only that the entropy of vaporization, which is the heat of vaporization divided by the absolute boiling point, is larger and more varying for the associated liquids, indicating, as stated above, the stronger attraction of the molecules for each other.

TABLE 2

	Entropy of vap. $\triangle S_{vap.}$	$\frac{d(\gamma v^{2/3})}{dt}$	ϵ	$\mu \times 10^{18}$
Normal liquids:				
Carbon disulfide	27.4	2.08	2.6	0
Benzene	27.4	2.10	2.3	0
Tin tetrachloride	27.2	2.20	3.2	0
Hexane	27.2	2.11	1.9	0
Associated liquids:				
Water	32.0	1.0	80.	1.9
Alcohol	33.4	0.9	25.	1.7
Acetone	28.2	1.7	21.	2.8
Ammonia	32.4	—	16.	1.5

The dielectric constant, shown in the third column of figures, has been interpreted in recent years, chiefly by Debye, in a way that has thrown much light upon our general problem.

Suppose that we have two metal plates that can be charged electrically, one positive, the other negative. If this is done in a vacuum, there is a definite amount of electricity stored up on applying a given electric potential; however, if the space between the plates is filled with a given liquid, a larger amount of electricity is absorbed before the same potential is reached. The ratio of the amount of electricity for this liquid to the amount in a vacuum is called its dielectric constant.

Now there are three ways in which this extra charge can be absorbed. In the first, the electrons present within the molecules are displaced relative to the positive atomic nuclei. The second way involves the stretching, twisting or bending of molecules by the displacement of atoms within the molecule. The third involves the orientation of molecules already possessing permanent electron displacements or dipoles, so as to bring the negative part of the molecule closer to the positive plate, and *vice versa*. It is obvious that of these three displacements only the third, the orientation, is seriously interfered with by the thermal agitation always going on in the liquid —the higher the temperature the less can orientation operate to increase the charge. By studying the change in dielectric capacity with temperature it is possible to disentangle this effect from the first two. The second or atomic polarization can be approximately "frozen" by solidifying the substance. The three effects can also be separated by the differences in rapidity with which they can respond to alternations of the field to which they are subjected. The electrons are very light; hence they can respond to frequencies even higher than those of visible light, a thousand million million times a second. The atoms can not respond to alterations more rapid than those of infra-red light only a million million times a second. The orientation of the whole molecule is relatively slow; it requires only the time of rapid radio frequencies, about a ten billionth of a second.

The distribution of the total polarization, a simple function of the dielectric constant, between these three effects is illustrated in Table 3 for several substances.

TABLE 3

MOLAL POLARIZATION

	Electron	Atomic	Orientation
HCN	6	7	140
HCl	8	1.2	22
HI	15	0.7	3
CCl_4	28	3.	0

It may be noted that the electron polarization is greater the more electrons there are in the molecule and the more loosely they are held; second, that the atomic polarization is relatively small, and third, that while the orientation may contribute by far the largest effect, it may be entirely absent.

It is found that the symmetrical compounds, CCl_4 and CH_4, as might be expected, have no permanent dipoles and hence no orienting power to be affected by temperature. However, the unsymmetrical intermediate compounds, $CHCl_3$, CH_2Cl_2 and CH_3Cl, show the effect of orientation, increasing as the temperature is lowered.

From this orientation polarization may be calculated the dipole moment or permanent displacement of the positive and negative electric charges relative to each other. This displacement is zero in an isolated atom, or when all the atoms in a molecule are alike, as in H_2 and Cl_2, or nearly so, electrically, as

in PL_3 and NCl_3, also when the molecular is geometrically symmetrical, as in CCl_4. The displacement increases with increasing difference in the electric character of the component atoms, one holding its electrons more loosely, approaching a more positive, metallic character, the other holding them more tightly, being more non-metallic, negative in character. We see this increasing shift of electrons towards the halogen in the series HI to HF. On substituting Na for H we get a compound, NaCl, in which the Na has completely "let go" of its outer electron. The slide shows other similar series.

Associated with this increasing electron displacement are highly characteristic properties, both in the liquid and solid states, as shown in Table 4.

such molecules build up solid crystalline lattices account in a general way for the differences in melting and boiling points, hardness in the solid state and electric conductivity in the liquid state.

It is possible, in a rough way, to calculate the dipole moment of a molecule from the relative "electro-negativity" of its atoms. Such a scale has been constructed from dipole moments themselves by Malone and Ferguson, also by Pauling, from totally different considerations. The two scales agree in the relative positions of the elements, which is, in order of increasing negativity, Sb, Te, H, As, P, Se, I, S, C, Br, Cl, N, O, F. Chemists will recognize, in part, the familiar electrochemical series.

The high negativity of oxygen and fluorine is in

TABLE 4

POLARITY AND PROPERTIES

Electron displacement	Zero		Increasing				Complete
Examples (with dipole moment)	H_2 0	Cl_2 0	HI 0.4	HCl 0.8	HF 2		NaCl
	PCl_3 0	NCl_3 0		PBr_3 0.6	PCl_3 1.0	$SbCl_3$ 3.1	BiF_3
			H_2Te	H_2Se	H_2S 1.0	H_2O 1.9	MgO
Liquid type	Normal Non-conducting Low boiling		Associated Non-conducting Higher boiling				Ionic Conducting Very high boiling
Solid type	(a) District molecules Low melting (b) Diamond type High melting		Polar lattice				Ionic lattice Salt type

Fig. 1 shows a highly symbolic illustration of the transition from the *"non-polar,"* or electrically sym-

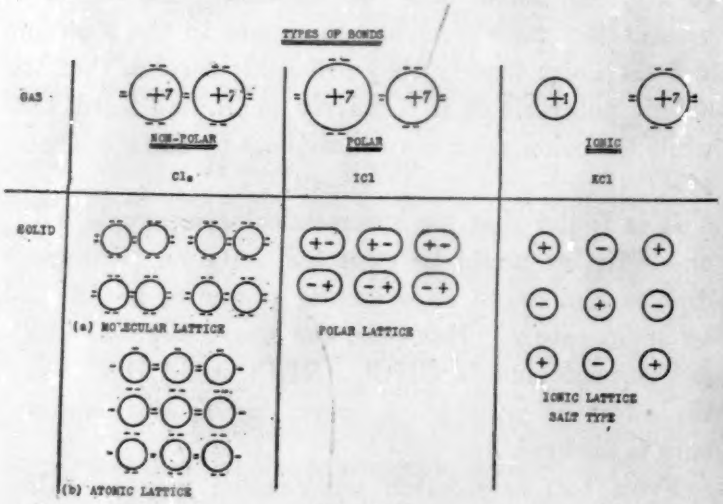

FIG. 1.

metrical molecule, through the *"polar"* or electrically unsymmetrical molecule, to the completely displaced or *"ionic"* molecule. The different ways in which

large part responsible for the highly abnormal character of water and of hydrogen fluoride. The boiling points of related molecules usually rise with the molecular weight, as shown by the series of the rare gases and by CH_4, SiH_4 and GeH_4 (Fig. 2). However, in the series H_2O to H_2Te, the smallest and lightest molecule, H_2O, forms the highest boiling liquid. The same effect is seen in the series HF to HI (and to a lesser degree with NH_3 to SbH_3). Water molecules show a very high electric field, which gives to water some remarkable and, for us, highly important properties. Non-polar molecules, unless they react with it chemically, are relatively insoluble in it, because they can not penetrate the strong electrostatic field which leads the water molecules to "prefer" the association of other like or similar molecules. On the other hand, it is the ideal solvent for salts. The process of solution of KCl by detachment of K^+ and Cl^- as independent "hydrated" ions is symbolically shown in Fig. 3, taken from my "Prin-

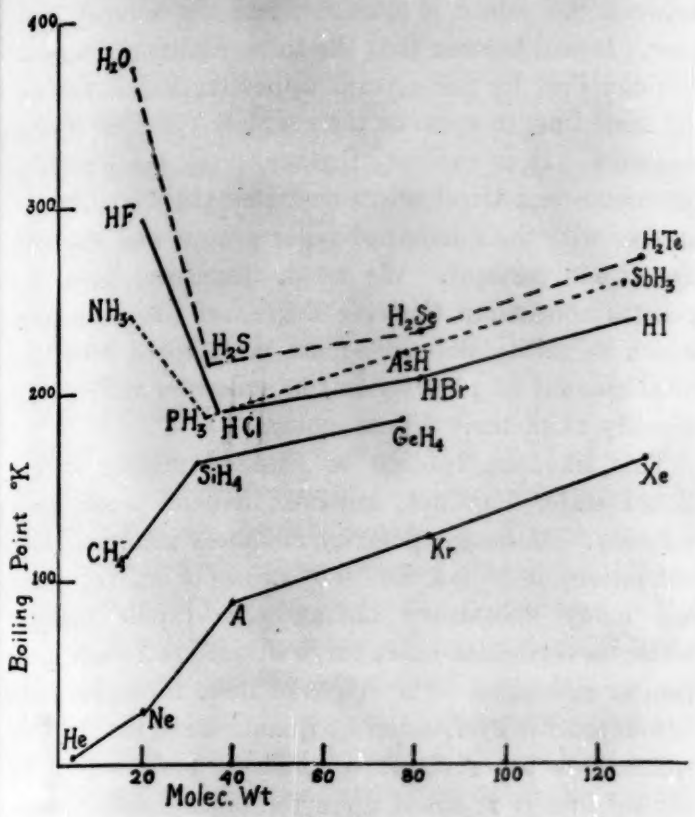

FIG. 2.

ciples of Chemistry." (The water molecules have been here simplified; actually the two positive hydrogen atoms form a right angle with the negative oxygen.)

Polar molecules can obviously form molecular aggregates with each other, and several types are possible, such as arrangement side by side or end to end. These structures suggest a sort of incipient crystallization, for which there is good evidence in the x-ray

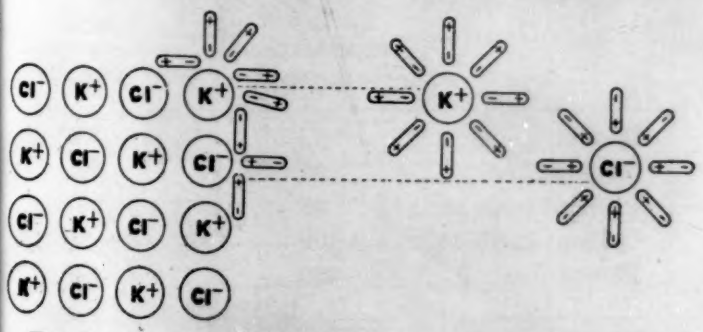

FIG. 3. Solution of Solid KCl in water to form ions.

studies of Stewart and others. He has called this condition "cybotaxis."

The solubility of a solid in a liquid is affected by polarity, but also by the melting point of the solid; hence we must allow for the latter if we wish to examine the former. Let us consider two substances, phenanthrene and anthracene, having identical composition, $C_{14}H_{10}$, and very similar molecular architecture. They both consist of three benzene "rings" or hexagons with one side of each in common. The three hexagons are arranged in a straight line in anthracene but are staggered in phenanthrene.

TABLE 5

	Molal vol. cc	Melt. pt.	Solubility Mole per cent. at 25° in benzene	Boil. pt.
Phenanthrene	174	99.6	18.6	340
Anthracene	142	218.	0.63	342

Each is undoubtedly non-polar, and the attractive forces exerted between neighboring molecules are practically identical in the two cases, as shown by their boiling points, which differ by only 2°. In the solid form, however, it is more difficult to pack into a close structure the crooked molecules of phenanthrene—just imagine sardines shaped like that—as shown by the volume of 174 as compared with 142 cc for anthracene. The phenanthrene molecules, being farther apart, attract each other less strongly, are nearer their condition in the liquid state, hence are more easily liquefied—the melting point is 118° lower than that of anthracene.

Now the phenomenon of solution is essentially one of liquefaction; the molecules are detached from a crystal lattice in each case to enter a "society" of liquid molecules in which the forces may be very much the same as if the solid were melted to form its own pure liquid. We see that phenanthrene is more soluble than anthracene in benzene, just as it is more soluble in liquid phenanthrene itself.

This effect of melting point is generally observable, unless masked by other causes. Let us now examine the effect of polarity after the effect of melting point has been subtracted.

TABLE 6

Dinitrobenzenes	Molal vol.	Melt. pt.	Solubility in benzene, 50°, mole per cent.	Boil. pt.
ortho	106.7	90	37.6	302
meta	105.7	116	17.5	319
para	103.4	170	3.1	299

We have here three dinitrobenzenes, each a benzene hexagon—itself non-polar—with two highly polar NO_2 groups substituted for hydrogen in the different positions. These differ in the closeness with which they can be packed in the solid state, as shown by their volumes per gram-molecule, and hence have different melting points and solubilities in benzene, which vary qualitatively with the melting points, as in the previous illustration. The melting points, how-

ever, do not necessarily tell the whole story, for the NO_2 groups are very polar, and this tends to make all nitrobenzene molecules associate with each other rather than wander about alone among benzene molecules. Benzene itself has zero dipole moment, while mononitrobenzene has a high moment.

TABLE 7

		Dipole moment (10^{18} e.s.u.)
Benzene		0.
Nitrobenzene		3.8
Dinitrobenzene	ortho	6.0
	meta	3.8
	para	0.
Trinitrobenzene, sym.		0.

The dinitrobenzenes have moments varying from 6 to 0, depending on whether the highly polar NO_2 groups supplement or oppose each other. Now if we should use the dipole moment of the whole molecule as the criterion of polarity, we would assume that benzene and nitrobenzene should behave somewhat as oil and water, not mixing with entire readiness, but that benzene and para-dinitrobenzene, both with 0 moment, should mix quite readily. We know, however, that in another sense the latter is not non-polar, for its zero moment is due only to the fact that its two polar groups are opposed. This may not prevent an adjacent benzene molecule from "feeling," as it were, that an electric field is in the vicinity, for the benzene molecule is small enough to be subject to the action of the separate NO_2 groups, regardless of their position. I have tested this fact by calculating the work that could be accomplished by distilling benzene into solutions of the various nitrobenzenes. This is shown in Fig. 4, plotted against the square of the mole fraction of benzene. The slope of the line indicates the amount of unlikeness in the fields of force

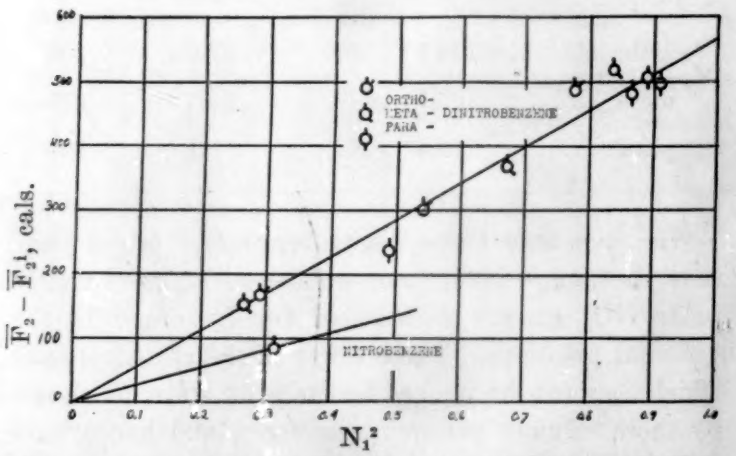

FIG. 4. Deviations from Raoult's law shown by solutions of benzene with nitrobenzene and with the dinitrobenzenes.

between the solute in question and the solvent benzene. It will be seen that the three dinitrobenzenes—distinguished by the several appendages—all fall on the same line, in spite of their widely different dipole moments. It is evident, further, from the lines for the mono- and trinitrobenzenes, that the deviation increases with the number of polar groups and not with the dipole moment. We must, therefore, reach the general conclusion that the degree of likeness, upon which solubility depends, must be deduced from the total amount of polarity in the molecules rather than directly from their dipole moments.

This likeness, leading to ease of mixing in the liquid state, does not, however, depend alone upon polarity. Although polarity enhances intermolecular attraction, it is not the sole cause of it, for there are many substances having zero dipole moment which nevertheless exert large attractive forces upon similar molecules. The origin of these forces has been accounted for by London by quantum mechanical considerations too difficult to indicate here, except by saying that it is based upon the mutual disturbances of the rapidly moving electrons in the two molecules. The magnitude of these forces, which I shall call the "internal pressure," can be estimated in several ways, but I will cite here only one, the energy required to vaporize 1 cc of the liquid.

Let us consider this quantity as a measure of the ability of unlike liquids to mix completely. We see here a series of liquids all having zero dipole moment

TABLE 8

	Energy of vaporization cals. per cc	Critical solution temp. with phosphorus
Decane	53	> 300°
Naphthalene	96	201°
Phenanthrene	98	200°
Carbon disulfide	109	- 6°
Phosphorus	200	—

but with increasing internal pressures, the highest being phosphorus. The lower its internal pressure the harder it should be for another liquid to mix with phosphorus; we see from the figures in the last column that this is indeed the case.

The substances which are gases at ordinary temperatures are, of course, characterized by small molecular forces and we might expect that their solubilities will be greatest in liquids of lowest internal pressure, and that they should be "squeezed out" more and more as we go to liquids of higher internal pressure. Here we see a series of solvents arranged in order of increasing internal pressures; only the last, water, is

TABLE 9

Solubilities of gases (100 × mole per cent.)

Gas	H_2	N_2	CO	CH_4	C_2H_4
Crit. temp.	33	127	132	177	283
Ideal solub.	.....	10	11	32	148
Solvent $\frac{\Delta E}{\Delta V}$					
Hexane	57	.....	.....	.....	31	159
Xylene	76	4.0	6.1	8.9	26	.....
Toluene	80	3.7	5.3	7.7	21	.....
Benzene	86	2.6	4.1	6.1	18	25
Carbon disulfide	109	.....	1.3	2.0	.....	.....
Water	520	0.15	0.13	0.19	2.4	8.4

polar. We see that the solubility of each gas falls off, as expected, as we descend the series. Water, which is highly polar, is by far the poorest solvent of all, for these gases are all non-polar. We may note, further, that the more easily a gas can be liquefied, as shown by its critical temperature, the more soluble it is in a given liquid.

Turning next to the solubility of solids, we will take as our first example the case of iodine. Liquid iodine is characterized by a very high internal pressure, hence iodine should go into solution more completely the higher the internal pressure of the solvent. Fig. 5 shows the solubility of iodine in a number of solvents in its variation with temperature. The solid lines are for solvents of zero or at least small polarity. They fall off in solvent power for iodine in exactly the order of their internal pressures. Moreover, they form a family of parallel curves, indicating a regularity which has led me to designate these solutions as "regular" and to derive formulas for their behavior.

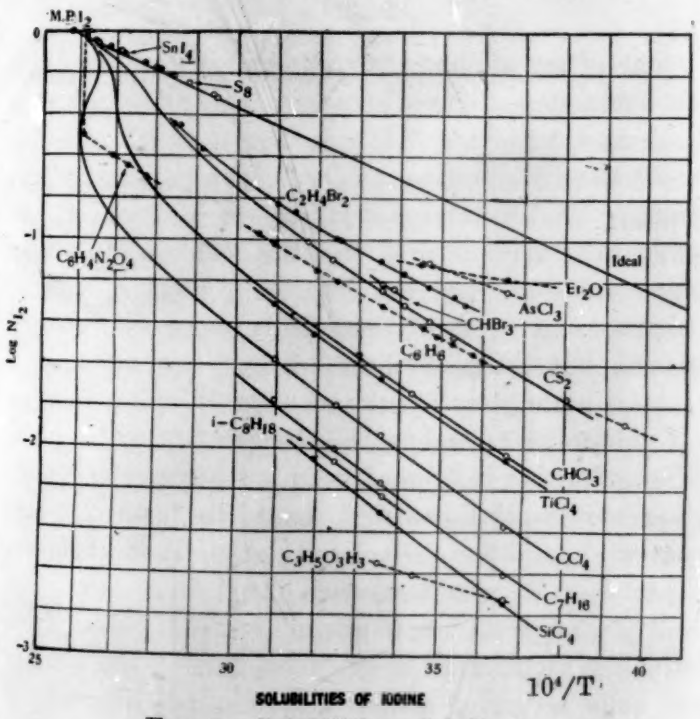

FIG. 5. Solubilities of iodine.

The dotted lines indicate solutions that are more individual in behavior and defy simple formulation. I have shown that they represent a loose chemical combination between iodine and solvent molecules. This causes a change in color from the violet of iodine vapor, and all the regular solutions, to various reds and browns.

The regularity exhibited in the effect of temperature upon the solubility in regular solutions has suggested that in spite of differences in intermolecular forces, their molecules are completely shuffled, as we might say, by the effect of the thermal agitation. Now molecular disorder is what the physical chemist calls entropy, and when he has information about the entropy he can connect the heat generated by a process, such as solution, with the work that might be performed, from which, in turn, the solubility can be calculated. This has been a complicated process, and I can only show the success of the result by comparing the measured with the calculated solubilities of iodine in several solvents.

TABLE 10

SOLUBILITY OF IODINE

Mole per cent. at 25°

Solvent	Observed	Calculated
Ideal	.....	22.0
CS_2	5.8	5.5
$TiCl_4$	2.1	1.7
CCl_4	1.4	1.6
$SiCl_4$	0.5	0.4

And now, finally, I will express much better the true spirit of science by ending, not with a blast of triumph, but with some indication of problems yet to be solved and of plans for their solution.

Before we can accurately relate the forces between two molecules to the energy of cohesion of a large number of molecules in the liquid state, we must have some knowledge of the structure of the liquid. A way to gain this has been shown by Menke, in Debye's laboratory. Let us imagine an assemblage of molecules thermally agitated, and hence not quite regularly arranged, such as is shown in Fig. 6, and consider the number of molecules whose centers are likely to be found in a series of spherical shells at different distances from a molecule selected as central. These imaginary shells are indicated by the dotted circles. We see that no molecular centers can fall within the first shell because it is smaller than the minimum distance to which two molecules can approach. However, a shell a little farther out, at a distance approximating the molecular diameter, will contain a number of molecular centers. Beyond this, again, the number diminishes, but reaches a second

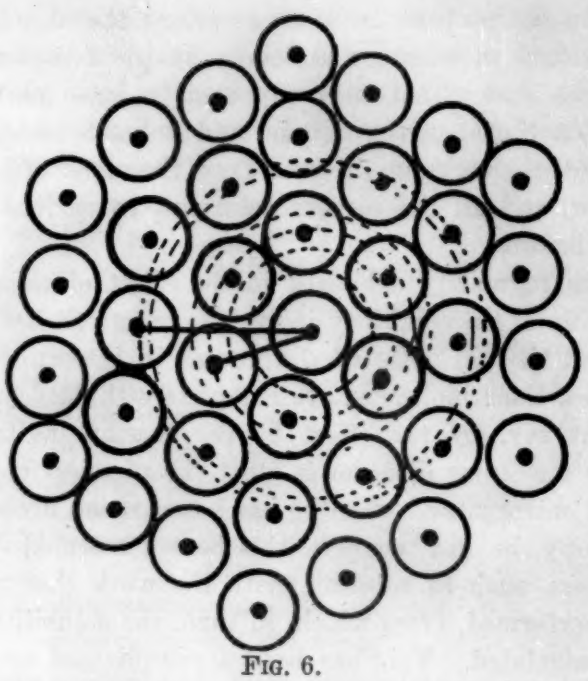

FIG. 6.

maximum at a little less than two diameters. As we proceed to shells farther and farther out, the influence of the central molecule becomes less and less in determining the position of other molecules, so that the number of molecules in a shell becomes, finally, just what one would calculate from the volume of the shell and the number of molecules in unit volume. The influence of the central molecule in causing departures from the average density of molecules at small distances is expressed in the form of a factor, called the "probability function" and designated by W. This is, of course, a function of the distance from the central molecule, and its form has been determined by Menke for mercury and gallium by means of x-ray diffraction. Fig. 7, Curve A, shows it for mercury.

If we use this function to calculate the average number of atoms of mercury at different distances from a central one, we get the smooth curve in B. It is interesting to compare this with the stepped line for solid mercury, where the number of surrounding atoms is, first, 6, then, at 3.5 Å, 12, then 18, etc. We can see how far this regular solid lattice has been blurred in going over to the liquid state.

With this knowledge of the average numbers of atoms at different distances it is possible to set up an expression for the potential energy of the whole assemblage, which is the energy liberated on condensation of the vapor. If the potential energy between two molecules varies inversely as the sixth power of the distance, as seems reasonably certain for non-polar molecules, the energy of vaporization is given by the area under the curve C. It is interesting to observe that the curve drops so nearly to zero at small distances as to show clearly that the immediately adjacent molecules alone contribute nearly all the energy of vaporization. Intermolecular forces in this respect behave very differently from gravitational forces, which fall off far more slowly with the distance.

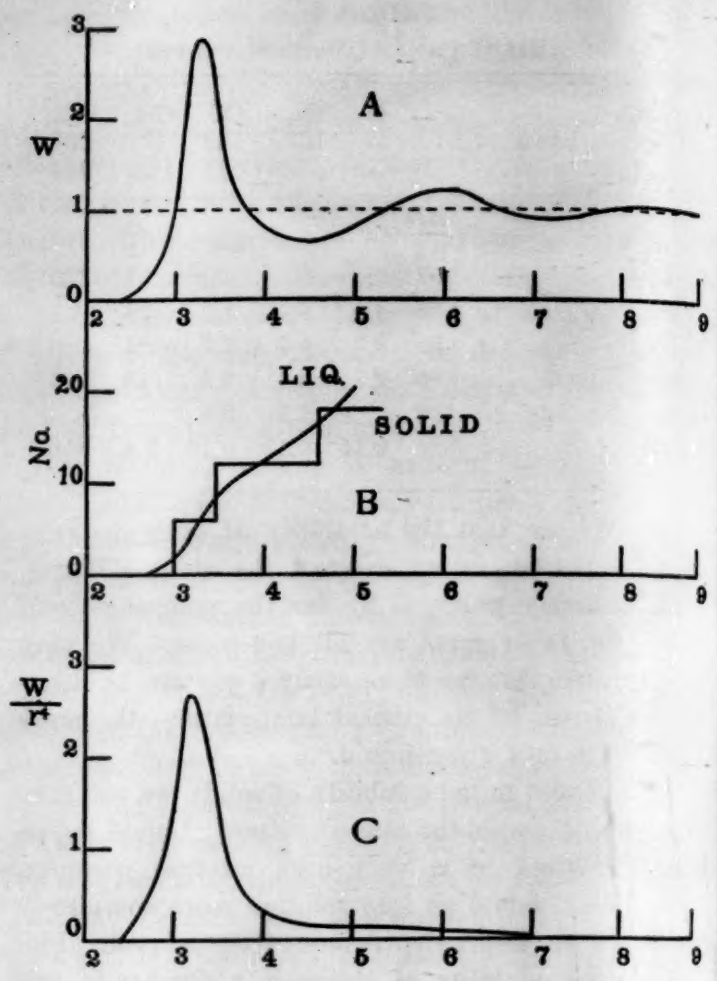

FIG. 7.

One of my students, Mr. Morrell, has checked this determination of liquid structure in a rather ingenious and amusing way. He has made model spherical molecules by allowing uniform drops of hot gelatin solution to fall through a tall column of cold oil. As they fall, they solidify to little solid gelatin balls. Into some of them are inserted centers of colored pigment. A mass of these balls, some with colored nuclei, but most of them without, are put into a cubical plate glass vessel and covered with a solution of gelatin that has ben boiled so that it will not set. The refractive indices of balls and surrounding solution are identical, so that the whole mass is transparent, except for the colored nuclei, whose distances apart can then be measured along three axes. The cell is shaken and new sets of readings taken, from which it is possible to calculate, finally, the number of balls occurring within certain small intervals of distance from each other. From this a "probability function" for each distance can be determined. It is shown in Fig. 3 by black circles connected by dotted lines in comparison with the solid curve of Menke for atoms (molecules) of mercury. In order to reduce them to the same scale, the unit of distance is the "molecular" diameter in each case. The correspondence is seen to be very good, the only difference being that the gelatine balls are more closely and hence regularly packed, so that the maxima are sharper and

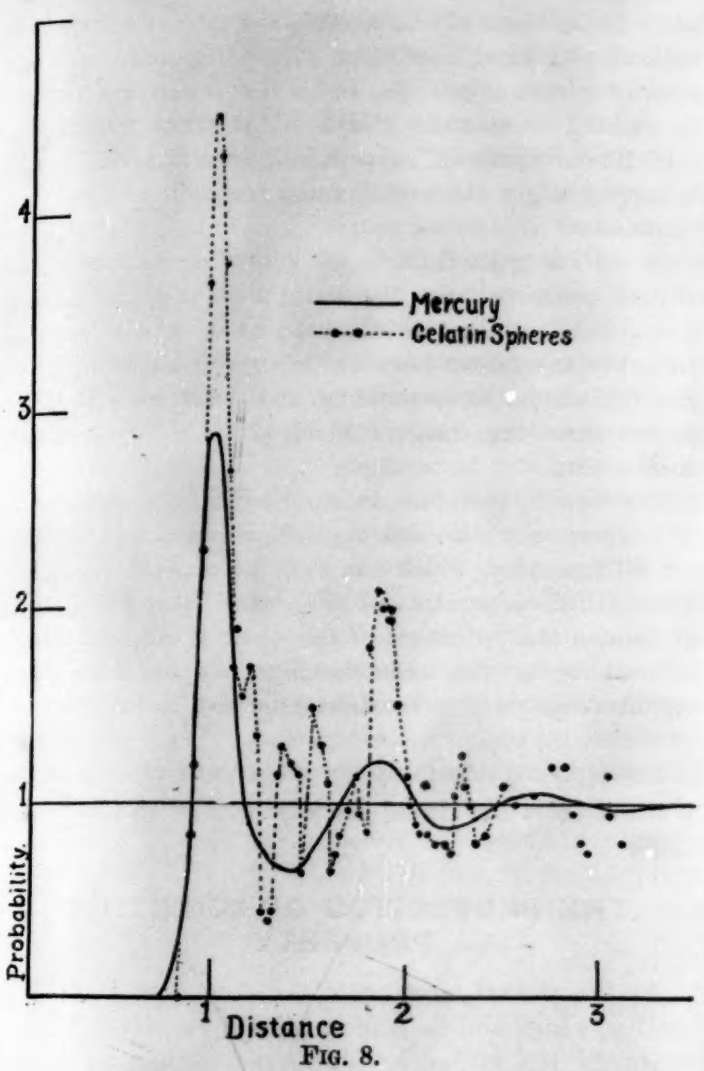

FIG. 8.

several sub-maxima appear. If the gelatin balls were more agitated and expanded, their curve would undoubtedly approach very closely to that for mercury.

Our plan is, next, to study the arrangement of balls of two sizes and different relative numbers together, corresponding to solutions of molecules of different volumes. This should permit a more rigid handling of our fundamental equations than is now possible, and make the calculation of solubilities an easy matter.

We are also studying molecules which are not spherical but shaped like sausages, and we have certain solubility data all ready to test our observations.

We are also making a comprehensive study of non-polar, highly symmetrical molecules, in pure liquid form and in their mixtures, which differ widely from each other in size and in intermolecular forces, and hence furnish crucial tests of various theories of solution.

This ends my exposition of the liquid state. I have tried to show that it represents a range in which the kinetic energy of the molecules is sufficient, on the one hand, to overcome the orienting forces which bind them into a rigid lattice, but is insufficient, on the other hand, to allow them to escape each others' attractions and fly apart into the gaseous state.

I have tried to show the existence of polar, orienting forces between molecules, also of non-polar forces, and how both of these depend upon the nature of the constituent atoms as well as upon their geometrical arrangement.

I have discussed the wide variations in strength of both types. We have considered the behavior of pure liquids made up of polar molecules and again of non-polar molecules. We have seen that light can be thrown upon the subject by the study of mixtures of molecules of the same and of different types, and that the important and complicated problem of solubility is susceptible to qualitative and, in the case of non-polar systems, to quantitative treatment.

I have tried to show, finally, that much still remains to be done, and that it constitutes an inviting field for research; not a spectacular one, for it corresponds, not to the discovery of large nuggets of gold, but rather to the working of large volumes of lower grade ore that has been passed over by the "forty niner" as not yielding immediate profits. It is good fun, nevertheless, if you are made so that you enjoy that sort of thing.

I will now show you, in conclusion, a beautiful experiment that illustrates the possibility of a substance remaining in the disordered array of the liquid state under conditions where it is ordinarily solid, simply because no organizer has appeared to start the formation of the regular ranks of the solid form. We see here what is known as a supersaturated liquid solution. On addition of a speck of crystal, as a nucleus for growth, large masses of solid rapidly separate.

A student once defined such a supersaturated solution as "one which contains more than it can hold." I hope that this, my lecture, does not leave you in a similar condition.

SCIENTIFIC EVENTS

THE INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS[1]

THE International Council of Scientific Unions (formerly the International Research Council) held its first triennial meeting, since its new statutes were adopted, on July 8–13 at Brussels. The general assembly of delegates met at the Palais des Académies, Brussels, and elected Dr. N. E. Nörlund, director of the Geodetic Institute and rector of the University of Copenhagen, president for the period 1934–37; General J. F. Bourgeois, of the Academy of Sciences,

[1] *Nature.*

Paris, and Marchese Marconi, president of the National Research Council of Italy, were elected vice-presidents. Dr. Pelseneer and Dr. Went remain members of the executive committee and Sir Henry Lyons the general secretary.

At this meeting for the first time, the International Unions of Astronomy, Geodesy and Geophysics, Chemistry, Scientific Radio, Physics, Geography and the Biological Sciences attended as members of the council, and communicated accounts of their activities in their respective scientific fields of work during the past three years.

For the first time also, addresses were given on scientific matters of general interest, and these included, on this occasion, one by Dr. D. la Cour on the International Polar Year, 1932–33, its aims, methods and some preliminary results; another by General G. Perrier, on recent international determinations of longitude; while Dr. E. P. Hubble spoke on the exploration of space, and Professor H. R. Kruyt on electricity and hydration with colloids.

The International Committee on the Relationship between Solar and Terrestrial Phenomena was reappointed, and another on instruments and methods met to arrange its future procedure.

The following motion, put forward by the Royal Academy of Sciences, Amsterdam, was unanimously adopted by the General Assembly:

> The International Council of Scientific Unions, being aware of the fact that the present economic and political difficulties have brought humanity face to face with a number of the most complicated and dangerous problems and threaten to erect a system of barriers between various nations, expresses its deep faith that ultimately a way will be found leading towards a more harmonious economic structure, and wishes to stress the importance of maintaining by all means international cooperation in the domain of science under whatever circumstances may present themselves.
>
> As laid down in its statutes, the council recognizes the relations between pure and applied science. There is no doubt that both governments and industrial groups will in an ever increasing degree call upon scientists for elucidation of the manifold complexities and problems which human life and human relationship are presenting —problems, the most important of which perhaps are those of finding food, space in which to live and employment for the various peoples spread over the earth. If at the present moment an international organization devoted to the solutions of these problems is still beyond our vision, and organization constructed according to national systems must provisionally be strengthened for fear of losing hold of economic possibilities, it can be foreseen that the scientists of every country will be drawn more and more into these spheres of national organization. The council expresses its confidence that scientists, while giving their aid in meeting the needs of their own nations, will never lose sight of the international character of science as a whole, and will ever continue to keep in working order and to develop the connections necessary for international cooperation, even if severe shocks unhappily might come to threaten economic and political relations.
>
> In professing its faith in the possibility and the necessity of peace between the world's peoples, the council points out that the "brotherhood of scientists" can be an important factor towards the establishment of a desire for mutual understanding and helpfulness in order to overcome the dangers involved in a too exclusive nationalism.
>
> The council, therefore, in emphasizing the significance of science, both pure and applied, as a common treasure for all humanity, which can only be realized through a free-spirited cooperation of the most diverse elements, is of opinion that scientists of the whole world have a task of working for this understanding, and urges all allied organizations to give constant attention to this task.

The General Assembly accepted unanimously an invitation from the Royal Society to meet in London in 1937.

THE PROTECTION OF SCIENTIFIC PROPERTY

AT the annual meeting of the American Bar Association, which will be held at Milwaukee, from August 27 to 29, the report of the section of patent, trademark and copyright law will be presented. The question of the protection of scientific property had been referred to a subcommittee consisting of Messrs. Robertson, Haynes and Willits, and the following report of the subcommittee was adopted and is submitted as the report of the Committee on Patent Law Revision:

> At the meeting of the Section of Patent, Trade-Mark and Copyright Law held at Grand Rapids in August, 1933, Mr. Richard Spencer (now First Assistant Commissioner of Patents) for the Committee on Scientific Property, reported as follows: "The committee commenced the investigation of this topic several years back and has from time to time reported its findings (*American Bar Association Journal*, January, 1932). At present it is cooperating with various scientific groups to learn whether the scientists themselves want protection. Rather extensive reports so far gathered indicate they do not. The subject, however, is not yet exhausted and it is accordingly recommended the subject be carried on the agenda another year."
>
> In January, 1934, the Council of the American Association for the Advancement of Science published an extensive bulletin entitled "Protection by Patents of Scientific Discoveries." This report (40 printed pages) was made by the American Association's committee consisting of Messrs. Joseph Rossman, F. G. Cottrell, A. W. Hull

and A. F. Woods, and probably contains the results of the investigation referred to by Mr. Spencer in his aforesaid report of August, 1933. In any event, the report of the American Association's committee of scientists contains a statement as follows: "A careful analysis of the whole problem, however, has led the committee to the opinion that no effort should at present be made to develop a plan for protecting scientific property. There appears to be no need for such legal protection from the viewpoint of incentive to the scientist or public policy. The committee recognizes that the present economic crisis has tremendously diminished the normally available funds for carrying on research so that other sources of potential funds are to be carefully considered at this time. It believes, however, that the legal and practical difficulties involved in enforcing any scientific property would eventually arouse an unfavorable public opinion against scientists, owing to the difficulty of enforcing scientific property and the inherent nature of its broad monopoly. . . . The committee's views being negative as to the first question asked by the American Bar Association it can not undertake to answer the second question in regard to indicating a feasible and practical way of affording this protection."

Since the scientists themselves have made a negative report, your committee recommends that no further study be given to this question at present and that the subject be dropped from the committee's agenda.

THE RECORD-BREAKING HEAT OF JULY

JULY brought record-breaking heat to the United States, notably to the Middle West and Southwest. Never before since the weather records began more than 60 years ago has the heat in any one month been so intense over so wide an area in this country, nor have such abnormally high temperatures persisted day after day without a break, according to J. B. Kincer, of the Weather Bureau. The nearest approach was in July, 1901.

The highest temperatures recorded for July this year in the Middle West and Southwest closely paralleled, and in many places topped the July, 1901, record in the same area. This year the highest ranged from 104 degrees, or 13 degrees above normal, at Oklahoma City, Okla., to 108 degrees, or 22 degrees above normal, at Des Moines, Iowa. At Columbia, Mo., the maximum of 112 degrees was 24 degrees above normal and at North Platte, Neb., the maximum of 108 degrees was 21 degrees above normal. In July, 1901, they ran from 102 degrees, or 11 degrees above normal, at Oklahoma City, to 109 degrees, or 23 degrees above normal, at Des Moines.

The number of successive days when the thermometer registered 100 degrees or over puts July, 1934, in a class by itself in the records of the Weather Bureau. Des Moines reported 12 days with 100 degree and higher temperatures; 9 of these were successive. In 1901, there were the same number of high-temperature days at Des Moines, but only 6 were in succession. Columbia, Mo., had 21 such days, with 16 in succession, in July, 1934, and 18 with 7 in succession, in July, 1901. North Platte, Neb., had 16, with 13 in succession in 1934, against 7, with 2 in succession, in 1901. Concordia, Kans., had 23, with 18 in succession, in July, 1934, and 19, with 10 in succession, in July, 1901. Oklahoma City, Okla., had 20, with 10 in succession, in July, 1934, and 4, with 2 in succession, in 1901. Fort Smith, Ark., had 24, with 17 in succession, in 1934, and 13, with 5 in succession, in 1901.

The average maximum temperatures for the two successive hottest weeks in both years' heat waves were uniformly higher in 1934 than in 1901. At Des Moines these average maxima for the two weeks were 102 degrees in 1934 and 101 degrees in 1901; at Columbia, 106 degrees in 1934 and 102 degrees in 1901; at North Platte, 103 degrees in 1934 and 98 degrees in 1901; at Concordia, 106 degrees in 1934 and 101 degrees in 1901; at Oklahoma City, 102 degrees both years; at Fort Smith, 104 degrees in 1934 and 101 degrees in 1901.

The 1901 heat wave broke permanently about July 26. The 1934 heat wave broke, temporarily at least, about the same time in the month, except in the more Southwestern sections, especially in the Southern Plains, where it continued.

The exceptionally high temperatures of July were preceded this year by very high temperatures in June in the Middle West and Southwest, which was not the case in 1901. For example, at Des Moines, Iowa, the July, 1901, mean temperature of 8.4 degrees above normal followed a mean June temperature only 2.6 degrees above normal. This year, however, at the same point the mean June temperature was 8.4 degrees above normal and the July mean, about 7 degrees above normal. At Columbia, Mo., another high temperature center in both years—the mean June temperature of 1.5 degrees above normal rose to 9.6 degrees above normal in July in 1901. This year the June temperature at Columbia was 7.6 degrees above normal and the July temperature, nearly 12 degrees above normal.

THE MINERAL RESEARCH PROGRAM OF THE MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

THE mineral research program authorized by the Federal Emergency Relief Administration and approved by the state planning board for the Michigan College of Mining and Technology, which is now under way, embraces the investigation and development of mineral resources and it is hoped to make it

a continuing program. It will provide constructive work for college people, and, as it is work which must be done in any event, the cost will be much lower than during prosperous times. The college will cooperate with all existing agencies, including the University of Michigan, the Michigan State College and the geological division of the Department of Conservation.

The program calls for investigation of mineral resources, methods of exploiting them and means of providing permanent industrial activity in the field. Among the general projects there are thirteen in the mining, metallurgical and geological fields and three in the electrical field. Research on copper and iron ore already in progress at the college will be continued.

In connection with iron ore research, attention is called to the fact that Michigan produces approximately 16,000,000 tons annually and now has a reserve estimated by the state appraiser of mines of about 175,000,000 tons of high-grade, merchantable ore. The reserve, which varies from range to range, will not last much over a decade.

There is, in addition to the merchantable ore, an enormous tonnage, now non-merchantable, of low grade iron formation. This has been estimated by various authorities at from three and a half to five billion tons. It contains enough iron to supply the entire demand for many hundreds of years. Like the "high grade" ore, this ore varies with the district. The problem is to make these non-merchantable iron formations acceptable as ore and thereby to add to the natural resources of the nation.

Low grade iron ores from all the ranges have been investigated, thousands of samples assayed and ores classified. The major portion of the work to date has been done on the ores of the Gogebic range, the development of a routine of practice and the invention and testing of machines. The iron formation of the Gogebic range has proven about 85 per cent. amenable to concentration. A machine has been developed which has definite promise of success on the coarsely crystalline ores.

In the work on copper, in the first two years of the formal research program, which has been carried out under the leadership of Dr. W. O. Hotchkiss, president of the college, a saving of 10,000,000 pounds of copper was effected and the practise outlined continues at this time. The companies themselves have inaugurated research programs.

THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES CHAPTER OF THE SOCIETY OF THE SIGMA XI

DURING the past year, the following Sigma Xi Lectures were given at the University of California at Los Angeles:

"Space and Time in Atomic Theory," by Dr. Niels Bohr, professor of physics in the University of Copenhagen.

"A Demonstration of Liquid Crystals," by Dr. G. van Iterson, professor of technical botany in the Technical High School of Delft.

"Results of Some Recent Researches," by Dr. R. A. Millikan, director of the Norman Bridge Laboratory of Physics and chairman of the Executive Council of the California Institute of Technology.

"The Molecule in Biological Structures," by Dr. O. L. Sponsler, professor of botany in the University of California at Los Angeles.

"The Realm of the Nebula," by Dr. Edwin P. Hubble, astronomer at the Mount Wilson Observatory of the Carnegie Institution of Washington.

"The Program of Earthquake Study in Southern California," by Dr. H. O. Wood, research associate of the Carnegie Institution of Washington and director of the Seismological Laboratory at Annandale, California.

"The Distances of the Stars," by Dr. W. O. Adams, director of the Mount Wilson Observatory of the Carnegie Institution of Washington.

"Greek Tradition in its Relations to Modern Science," by Dr. E. T. Whittaker, professor of mathematics in the University of Edinburgh and Hitchcock Lecturer at the University of California. Dr. Whittaker also delivered a second lecture on "Mechanism *vs.* a Pan-Mathematical Theory of the Universe."

"A Study of Oceanography of the Pacific," by Dr. T. Wayland Vaughan, professor of oceanography in the University of California and director of the Scripps Institution of Oceanography at La Jolla.

"The Causes and Effects of Earthquakes," by Dr. J. P. Buwalda, professor of geology at the California Institute of Technology.

On June 11 the university chapter initiated one new member and twenty-one new associates. The officers of the chapter for the past year were: Dr. S. J. Barnett, *President;* Dr. B. M. Varney, *Vice-president;* Dr. E. K. Soper, *Secretary,* and Dr. H. W. Stone, *Treasurer.* New officers for the coming year were elected as follows: Dr. B. M. Varney, *President;* Dr. G. Ross Robertson, *Vice-president;* Dr. E. K. Soper, *Secretary,* and Dr. H. W. Stone, *Treasurer.*

E. K. SOPER,
Secretary

SCIENTIFIC NOTES AND NEWS

ON his retirement from the directorship of the Department of Genetics of the Carnegie Institution of Washington, Dr. Charles B. Davenport addressed the members of the department on "Reminiscences of Thirty Years." He was given a purse of over $150 to purchase books and fifteen bookplates, each con-

taining seventy signatures of the members of the department. Mrs. Davenport was presented with a bouquet of thirty tea roses.

A SPECIAL committee has been named from among the trustees of the Johns Hopkins University to make recommendations for a successor to Dr. Joseph S. Ames, retiring president. Dr. Ames was professor of physics from 1899 to 1926. The committee includes Newton D. Baker, chairman; B. Howell Griswold, Jr., Carlyle Barton, Dr. Thomas R. Brown and Walter S. Gifford.

DR. ERNST GELLHORN, professor of physiology at the College of Medicine of the University of Illinois, Chicago, has been awarded the Alvarenga Prize for the year 1934, for a paper entitled "The Influence of Parathormone on the Neuro-muscular System."

THE Division of Medical Science of the University of Chicago has awarded the Howard Taylor Ricketts Prize for 1934 to Drs. Paul E. Steiner and Thomas C. Grubb. Dr. Steiner was given recognition for his work on "The Rôle of the Avian Tubercle Bacillus in the Etiology of Hodgkin's Disease" and Dr. Grubb for his work on "Studies on the Coccus Forms of Corynebacterium Diphtheriæ."

THE Messel Memorial Medal of the British Society of Chemical Industry was presented on July 19 to Sir Harry McGowan, chairman of Imperial Chemical Industries, Limited, at the annual meeting at Cardiff. Sir Harry delivered an address entitled "The Uneven Front of Research."

THE Georges Kohn Prize of the Institute of Oceanography, Paris, has been awarded to M. Le Gall, director of the laboratory at Boulogne, for his work on the biology of the herring. The prize for 1935 will be awarded for work on the origin and relations of the Antarctic fauna.

THE title of doctor honoris causa has been conferred by the University of Paris on Dr. A. Eiselberg, emeritus professor of surgery in the faculty of medicine of the University of Vienna.

M. PAUL LANGEVIN has been elected a member of the Paris Academy of Sciences in the section of general physics to succeed the late M. P. Villard.

DR. WILLARD COLE RAPPLEYE, dean of the College of Physicians and Surgeons, Columbia University, has been appointed dean of the School of Dental and Oral Surgery. He has been acting dean during the absence of Dr. Alfred Owre, who has now resigned.

DR. ALFRED FRIEDLANDER, professor of medicine, University of Cincinnati College of Medicine, has been appointed dean of the college, to succeed Dr. Arthur C. Bachmeyer, resigned.

IRA E. NEIFERT, of Knox College, has been promoted to the Herbert Griffith professorship of chemistry.

AT Duquesne University, Pittsburgh, Dr. M. A. Rosanoff, sometime graduate professor of chemistry in Clark University, and later Willard Gibbs professor of research in pure chemistry at the Mellon Institute in Pittsburgh, has been appointed dean of the graduate school. Dr. Roland Schaffert, of the University of Cincinnati, will be instructor in physics and Dr. Noel E. Foss, of the University of Maryland, will be instructor in pharmacy and chemistry in the School of Pharmacy.

DR. ARTHUR W. MELTON and Leonard W. Doob have been appointed instructors in psychology at Yale University, and Dr. Frances L. Ilg has been appointed instructor in the Clinic of Child Development.

M. IDRAC, chief of work in physics at the Polytechnic School at Paris, will succeed the late Alphonse Berget, as head of the department of physics at the Institute of Oceanography.

PROFESSOR L. R. WILBERFORCE JONES, professor of physics at the University of Liverpool, will retire from active service on September 30.

AT the University of Leeds, E. R. Flint has been elected to the chair of clinical surgery in succession to the late Professor Alfred Richardson. Mr. Flint will also retain the directorship of surgical research which he has held during recent months. H. W. Thompson, of the advisory staff of University College, Cardiff, has been appointed advisory entomologist on the staff of the department of agriculture.

ANNOUNCEMENT of the following appointments in London is made in *Nature:* Professor H. E. Watson, professor of general chemistry at the Indian Institute of Science, to be Ramsay Memorial professor of chemical engineering, in University College; Dr. A. B. Appleton, lecturer in anatomy in the University of Cambridge, to be professor of anatomy, in St. Thomas's Hospital Medical School; Dr. S. P. Bedson, senior Freedom research fellow at the London Hospital, to be the Goldsmiths' Company's professor of bacteriology, in London Hospital Medical School; Professor F. R. Fraser, university professor of medicine at St. Bartholomew's Hospital Medical College, to be professor of medicine in the British Postgraduate Medical School; Dr. James Young, lecturer in clinical obstetrics and gynecology in the University of Edinburgh, to be professor of obstetrics and gynecology, in the British Postgraduate Medical School; Professor E. H. Kettle, since 1927 university professor of pathology at St. Bartholomew's Hospital

Medical College, to be professor of pathology in the British Postgraduate Medical School.

DR. RAPHAEL ZON, director of the Lake States Forest Experiment Station, has been assigned to forest service to take charge of technical phases of the great plains tree shelter project. He will collaborate with Fred W. Morrell, recently appointed administrator of the project. Dr. Zon will develop technical methods to be used in raising nursery stock and in planting trees over an area 100 miles wide and 1,300 long.

PROFESSOR L. F. MAREK, formerly acting director of the research laboratory of applied chemistry at the Massachusetts Institute of Technology, has joined the staff of Arthur D. Little, Inc., chemists and engineers, of Cambridge, Mass.

DR. A. O. BOWDEN, president of the New Mexico State Teachers College, has been appointed director of the California Branch of the School of American Research of the Archeological Institute of America, which has its headquarters at the University of Southern California. Dr. Edgar L. Hewett, president of the institute, will continue to direct the field work.

DR. ALLEN E. SEDGWICK, professor of geology at the University of Southern California, has been elected president of the Board of Education of the Los Angeles city schools.

E. BARNARD has been appointed director of food investigation in the British Department of Scientific and Industrial Research, and Dr. F. Kidd to be superintendent of the Low Temperature Research Station, Cambridge. Both these posts were previously held by the late Sir William Hardy. Mr. Barnard has been assistant director of food investigation since 1931 and Dr. Kidd has been on the staff of the Low Temperature Research Station since its establishment in 1922.

DR. HENRY FAIRFIELD OSBORN, honorary president of the American Museum of Natural History, sailed for Europe on August 1.

DR. KLADIM VLADIKOFF, of the Biological Board of Canada, is investigating this summer the relationship between the temperature of the water and the catch of fish.

ROGER REVELLE, of the Scripps Institution of Oceanography, has gone to Bremerton, Wash., for a trip to the Aleutian Islands, where he will collect water samples at different depths, ranging as low as 2,000 fathoms, and make records of sub-surface temperatures.

The British Medical Journal reports that the council of the Royal Society of Arts attended at Clarence House on July 11, when the president, the Duke of Connaught, presented the Albert Medal for 1934 to Sir Frederick Gowland Hopkins, "for his researches in biochemistry and the constituents of foods." In making the presentation the Duke of Connaught said: "Your work has largely lain in the domain of pure biochemistry. Your discoveries have not only enriched this science, but have done much to make it a distinctive subject for study, attracting a large and enthusiastic body of research workers. Actually the discovery that foodstuffs contained certain factors now called vitamins, and that life could not be maintained on a synthetic diet alone, gave a new impetus to work on nutrition and to the study of deficiency diseases, in which work you have continued to take an active part. In consequence the world has acquired a clear conception of the vitamins, of the part they play in health and disease, and their distribution in various foods. As a further result, nutrition, the feeding of a nation, is becoming a more exact science, to the benefit of the health of everyone. Of no less consequence to the general advance of science has been your personal willingness at no small sacrifice of comfort and leisure to give help at all times and in every way to scientific workers and associations with scientific aims. I have the greatest pleasure in handing you this medal, which was founded as a memorial to my dear father in 1862."

ACCORDING to *Nature*, a preliminary program is now available of the General Discussion on Colloidal Electrolytes to be held by the Faraday Society at University College, London, on September 27, 28 and 29. Professor H. Freundlich will deliver an introductory paper, and papers in the remaining sessions will be grouped according as they deal with theory, experimental technique or special subjects (soaps, dyestuffs, silicates, proteins, and so on). The papers, which will be available in advance, will be taken as read; each author will indicate a few points of special interest, after which the subject will be open for discussion. Among those outside Great Britain who are contributing papers are Dr. E. J. Bigwood, Brussels; Professor P. Debye, Leipzig; Professor E. Elod, Karlsruhe; Professor A. Frumkin, Dr. Proskarnin and Professor A. J. Rabinovith, Moscow; Professor E. Hammarsten, Stockholm; Professor H. R. Kruyt, Utrecht; Professor Linderstrom-Lang, Copenhagen; Professor A. Lottermoser, Dresden; Professor J. W. McBain, Mrs. M. E. Laing McBain and Margaret M. Barker, Stanford University; Professor W. Pauli, Vienna; Professor M. Sameč, Ljubljana; Professor A. Treadwell, Zurich, and Dr. F. Valko, Ludwigshafen a/Rh.

THE trustees of the Beit Fellowships for Scientific Research have awarded the following fellowships for research at the Imperial College of Science and Tech-

nology during the academic year 1934–35: H. I. Stonehill, Central Foundation School, 1922–29, and East London College, 1929–34, for research into the applicability of the modern theories of strong electrolytes due to Debye, La Mer, Bjerrum, Davies, etc., the experimental work taking the form of measurement of the E.M.F. of certain cells, under Professor J. C. Philip; J. R. Tillman, Gillingham County School, 1923–30, and the Imperial College, 1930–33, for research on electron diffraction, both from the point of view of studying crystal forms and the mechanism of diffraction, under Professor G. P. Thomson; J. Bell, Whitehaven Secondary County School, 1919–27, and the Imperial College, 1927–34, for a spectrographic investigation of hydrocarbon combustion, under Professor W. A. Bone.

ABOUT 350 men, supported and controlled by the Federal Government, through the Wisconsin Emergency Relief Administration and its state transient bureau, began work recently on fifteen or more projects designed to develop the arboretum of the University of Wisconsin, which was established two years ago, into an out-of-door laboratory for wild game conservation experimentation in the Middle West. The government is constructing barracks, providing equipment and materials, and supporting the men, no state or university funds being expended. Establishment of the camp on the arboretum grounds necessitates the expenditure by the government of upwards of $50,000 for equipment and materials and approximately $100,000 for labor. The work is under the direction of the arboretum committee, Professor Aldo Leopold, research director, and Professor G. W. Longenecker, executive director.

ACCORDING to a correspondent of the *Journal* of the American Medical Association, in 1933 the number of living births in Europe showed a further decline. According to a preliminary report, the greatest decrease occurred in the east European countries, which still have a comparatively high birth rate. In Roumania, in the first six months of 1933, there were 42,000 (12.4 per cent.); in Poland, 35,400 (7.5 per cent.), and in Czechoslovakia, 12,800 (7.9 per cent.) fewer children born than in the first half of 1932. In Hungary the number of births for the first nine months of 1933 was 8.8 per cent., and in Lithuania 7.7 per cent. lower than for the corresponding period of the previous year. The decline in the number of births was very marked in Austria (6.2 per cent.) and in Bulgaria (6.0 per cent.). In France, which has had, since the war, a comparatively steady birth rate, 33,110, or 6.0 per cent. fewer living births were recorded for the first nine months of 1933 than in the corresponding months of 1932, whereas the decline in births for the previous year in France was less than 8,000. For the period of nine months Great Britain reports a decrease in the number of living births amounting to 26,450, or 4.7 per cent., and the Netherlands a decline of 4.4 per cent. In the German Reich, however, in consequence of the slight increase of births in the third quarter, the total number of living births for the corresponding nine-month period was only 21,100, or 2.8 per cent., fewer than for the same period of the previous year. Thus, in 1933, the German Reich stood, for the first time in many years, among the countries with a relatively slight decline in the birth rate, by the side of Spain, Portugal, Switzerland and Italy.

DISCUSSION

TRANSFORMATION OF BACTERIA

DR. W. H. MANWARING'S extremely interesting discussion printed in SCIENCE of May 25 ends with a question concerning the possibility of harmonizing the "apparent Lamarckian world of bacteriology and the presumptive Darwinian world of higher biological science."

Assuming that all the facts related by him are correctly stated, it does not seem probable to me that there is any fundamental difference between the vital processes of bacteria and those of other organisms. Among the Coccidae or scale insects, the sexes are extremely different, so that if we did not know the life history, they might be placed in different orders or families. Some species reproduce parthenogenetically, and the males are never seen, or in certain cases are seen very rarely. Locked in the germ plasm of the female coccid is the potentiality of a being far more different from the female than any of the new types of bacteria arising as described by Dr. Manwaring are from their progenitors. If all coccids became parthenogenetic, no one would suspect this to be the case, yet under certain circumstances one of the extraordinary males might suddenly appear. No one would consider this a case of mutation; it would be recognized as an example of the bringing to light of hidden germinal potentialities. In my recent studies of bees, I have been struck by the sporadic appearance of complex structures, and without going into details, it may be said that the evidence strongly indicates the functioning of latent genes, rather than the appearance of new mutations.[1]

It seems probable that among the bacteria organization is comparatively loose, so that the germinal

[1] Cockerell and Ireland, *Proc. Nat. Acad. Sci.*, p. 972, November, 1933.

elements are more easily disturbed and broken apart than is the case among more complex organisms. The study of fossils shows the extraordinary permanency of structures in the higher animals and plants. It may well be that the cytoplasm, in addition to its other functions, serves to protect the chromosomes from such disintegrating influences as are described by bacteriologists. The phenomena of crossing over show how readily a part of a chromosome becomes attached to another, and by analogy it is easy to understand why bacteria so readily "take on" free genes. Dr. Manwaring says: "Transmissible bacterial genes are apparently widely distributed in nature, being found, for example, in almost any contaminated surface water." The "polyvalent" genes may really be aggregates of two or more. It is conceivable that we may return to a sort of Darwinian pangenesis, and postulate the existence of many kinds of "free genes," which are ready to unite with the organized systems of genes when they have a chance. Some bold experimenter, perhaps using sperm cells on account of the absence of the thick cytoplasmic covering, may one of these days succeed in adding genes to the germinal elements of the higher organisms.

What we now want to know is whether the "dissociated genes" arise *de novo* from inorganic or non-living sources or whether they are always the result of the breaking up of living systems. Just as the inorganic letters of the alphabet c, a, t, when united give us the organic cat, so it is conceivable that the genes owe their significance as vital units to their being parts of a system, and not to any special "vital" properties of their own.[2]

In any case, we have plenty of evidence to show the extraordinary stability of genes in nature, their persistence during many millions of years, under all sorts of diverse conditions. This stability may in a sense be a product of natural selection, since it is essential for the processes of evolution and adaptation. Nature can not build on a quicksand. It does not seem probable that the phenomena described by Dr. Manwaring can be ascribed to perpetual or very frequent gene mutations, or to specific changes in genes induced by particular environmental factors. According to this view, bacterial genes may be about as stable as others, and there is no "Lamarckian world of bacteriology."

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DARWIN'S VIEW OF HEREDITY

IT seems that in the interest of modernity we ought to demonstrate the fallacies of our predecessors. One of the favorite methods adopted for this end is to schematize the theories of earlier workers and then show how modern advances have shown these schemes to be untenable. It seems to me that the time has come, however, when text-book writers ought to check over more thoroughly the written works of the author whose theory is being criticized. The particular instance of this which is rapidly becoming my private grouch is the apparent wide-spread belief that Darwin believed all variations to be inheritable, and thus grist for the natural selection mill. In a fairly recent text-book, for instance, there occurs the statement, "Darwin believed that all differences among individuals were hereditary."

I would like to call attention to some quotations from Volume 2 of Darwin's "Variation of Animals and Plants under Domestication." In the first paragraph of chapter 12: "It is obvious that a variation which is not inherited throws no light on the derivation of species, nor is of service to man, except in the case of perennial plants, which can be propagated by buds." Again, about two thirds of the way through the same chapter: "When a new peculiarity first appears, we can never predict whether it will be inherited."

It is true that he also stated, in Chapter 28, that "we are led to conclude that species have generally originated by the natural selection, not of abrupt modifications, but of extremely slight differences." This has frequently been stressed as a difference between his and more recent theories which stress mutations. Since, however, mutations no longer signify large abrupt changes alone, but simply heritable variations, however slight, and since we have found that the larger share of these are very slight alterations, it seems something of a quibble to say that, since Darwin did not believe that "sports" were especially significant in evolution—a view which modern geneticists would subscribe to if "sports" mean such large modifications as they did in Darwin's day, *e.g.*, moss roses, hornless cattle, etc.—his view differs so radically from such a view as is, for instance, incorporated in Morgan's "Scientific Basis of Evolution."

With the hope that this protest will lead an occasional biologist either to glance through for the first time or to review once more one of Darwin's most significant contributions to scientific literature, I submit it.

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TERRACES IN THE SUSQUEHANNA VALLEY BELOW HARRISBURG, PENNSYLVANIA

DURING the summer of 1931 the writer made a study of river terraces in the Susquehanna Valley

[2] For a discussion of the gene as the unit of life, see Hurst, "The Mechanism of Creative Evolution," Chap. XVII, 1932.

south of Harrisburg, Pennsylvania. The investigation, which was sponsored by the American Geographical Society, the Carnegie Institution of Washington and Columbia University, was under the direction of Professor Douglas Johnson and was carried on in cooperation with the Pennsylvania Geological Survey. Publication of the formal report has been delayed, but certain of the conclusions have been briefly set forth in a recent bulletin[1] of the Pennsylvania Survey, prepared by the director, Dr. George H. Ashley. The writer's responsibility to the sponsors of the investigation for these conclusions prompts publication of this statement.

In 1928 Leverett published a brief note[2] in which he reported Illinoian pebbles approximately 100 to 120 feet above the Susquehanna at Harrisburg. These pebbles occur on a stream-cut, gravel-mantled rock terrace that is well developed throughout the Great Valley-Triassic Lowland section of the Susquehanna Valley. The terrace stands at the same or nearly the same elevation as broad lowlands of the well-known Somerville peneplane (400 to 420 feet above sea level, or 90 to 110 feet above the river near Harrisburg). This relationship was interpreted by the present writer to mean that the terrace was formed by the lateral swinging of the Susquehanna River during the same pause in downcutting that permitted reduction of weak limestone belts to the Somerville peneplane by weathering and solution. The presence of rock types foreign to the drainage basin of the Susquehanna in the Somerville terrace gravels (laid down *pari passu* with the cutting of the rock benches) indicated that the Somerville cycle was interrupted during or after the advance of some ice-sheet into the drainage basin. On this evidence the writer fixed the age of the Somerville peneplane as Pleistocene. If Leverett's correlation is correct, the age of the Somerville is more definitely fixed as Illinoian or post-Illinoian Pleistocene.

Topographic maps of the terrace surfaces at and below Harrisburg were prepared by the writer with the able assistance of Dr. William O. Hickok and Mr. Forrest T. Moyer, both of the Pennsylvania Survey. A part of one of these maps, printed in the bulletin, is, through oversight, specifically credited in the legend and the accompanying text to Hickok and Moyer alone.

The original purpose of the terrace study was the investigation of the "knickpoint" concept, applied in the interpretation of the erosional history of the Susquehanna Valley by E. B. Knopf[3] in 1924. Hickok has extended the application of this concept in a recent publication.[4] Ashley, in the bulletin mentioned above, leaves the issue open. The writer takes this opportunity to state his conclusions in regard to the "knickpoint" theory, in advance of the publication of the complete report. These are, briefly, that as originally found by Stose,[5] the terraces slope downvalley; that the profile breaks considered by Knopf and Hickok to be cyclic ("knickpoints") are due rather to resistant rocks in the river bed; and that only two post-Harrisburg cycles (the Somerville and the present cycle) are recognizable in the Susquehanna Valley, as opposed to four found by Knopf and eight by Hickok.

J. HOOVER MACKIN

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[1] George H. Ashley, "The Scenery of Pennsylvania," Pennsylvania Topographic and Geologic Survey: *Bulletin G 6*, 1933.

[2] Frank Leverett, "Results of Glacial Investigations in Pennsylvania and New Jersey in 1926 and 1927" (abstract), *Bull. Geol. Soc. Am.*, 39: 151, 1928.

[3] E. B. Knopf, "Correlation of Residual Erosion Surfaces in the Eastern Appalachian Highlands," *Bull. Geol. Soc. Am.*, 35: 633–668, 1924.

[4] William O. Hickok, "Erosion Surfaces in South-Central Pennsylvania," *Am. Jour. Sci.*, 5th ser., 25: 101–122, 1933.

[5] G. W. Stose, "High Gravels of the Susquehanna River above Columbia, Pennsylvania," *Bull. Geol. Soc. Am.*, 39: 1073–1086, 1928.

A NEW HORIZON FOR THE EXTINCT GOOSE, CHENDYTES

THROUGH the kindness of Dr. Chester Stock I have been permitted from time to time to examine fossil bird remains in the collections of the California Institute of Technology. Based on a single specimen from Ventura County, this note is offered as a record of the following points:

(1) A new bird-bearing locality—the twenty-third for the state of California.

(2) The third station for *Chendytes lawi*, an extinct diving goose.

(3) An extension downward of the known range of this species from Upper San Pedro to Lower San Pedro.

The specimen referred to is a single complete left tarso-metatarsus No. $\frac{211}{1670}$, California Institute of Technology from south flank of the Ventura anticline, west bank of Sexton Cañon, 800 feet south of intersection of Lake Cañon, 350 feet above the base of the San Pedro formation. Except for a slight degree of slenderness, the specimen is identical in character with one of the same segments from Arnold's Lumber Yard Station at San Pedro (Upper San Pedro Formation). The difference in stoutness is not greater than is evident within the species limits of any of our modern geese.

The type locality of *Chendytes* is at Santa Monica in shell beds 150 feet above the sea and about a mile

back from the present strand line. Tibia and tarsus were the parts retrieved here by Dr. F. C. Clark, of Santa Monica. The two segments were assigned to the same species on purely biological grounds, there being no immediate proximity within the matrix.

Later an almost exact duplicate of the tarsus was taken at Arnold's Lumber Yard locality in San Pedro thirty miles to the southeast. Here also were found specimens of a femur that were ascribed to the same species, again on purely biological grounds. The specimen from Ventura is considered to be of Lower San Pedro age, whereas the former specimens are from Upper San Pedro. Just what is the time hiatus between Upper and Lower San Pedro remains uncertain, but there is evidence of considerable orogeny having taken place in the interim. This was very generously checked for me by Dr. U. S. Grant in oral discussion of the Ventura area. Bird species are apparently of rather long life span compared with mammals, hence there appears no cause for challenge of identity on the basis of age. Molluscan species associated in the matrix include *Nassarius fossatus* Gld., *Olivella pedroana* (Conrad) and *Cryptomya californica* Conrad.

LOYE MILLER

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WHY DANDELIONS?[1]

A RECENT investigation at the Massachusetts Agricultural Experiment Station has thrown more light on the food value of the common dandelion.

Dandelions in the form of greens have had a place in our diet in the spring of the year for generations. The indulgence in green foods of this kind was very appropriate after a long winter diet of cured or preserved foods. The literature, however, confirms the suspicion that people ate such things largely because they liked them and not because of any specific knowledge of their nutritional value.

Results obtained at this station have shown the dandelion to have a high protein (15.76 per cent.) and a very low fiber (9.79 per cent.) content, accompanied by a high ash, and to contain such minerals as calcium and phosphorus in abundance.

A comparison has been made of the amounts of some of the minerals with that found in other vegetables commonly used as greens.

(*Dry matter*)	*Ca* Per cent.	*Mg* Per cent.	*P* Per cent.
Dandelions	1.60	0.46	0.51
Mangold leaves[2]	1.20	0.89	0.18
Lettuce (common)[2]	0.59	0.20	0.26
Cabbage leaves[2]	1.82	0.33	0.28
Spinach[2]	1.40	0.62	0.36

[2] Analyses given in "Compilation of Analyses," Massachusetts Agricultural Experiment Station, 1919.

The dandelion contains much more phosphorus than any of the others listed and is exceeded only by cabbage leaves in calcium and by mangold leaves and spinach in magnesium. Spinach, probably the most popular of those mentioned, is slightly lower than the dandelion in content of calcium and significantly lower in phosphorus. The dandelion can therefore be rated as an excellent source of these minerals. Perhaps we may therefore say that our taste is not as fallacious as we sometimes think.

EMMETT BENNETT

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DR. BRITTON'S INTEREST IN MINING AND GEOLOGY

DR. H. H. RUSBY'S excellent obituary of N. L. Britton, in your August 3 issue, omits something that would have thrown interesting light on the story of how the Director of the Botanical Garden, to avoid an annoying delay, went out and personally ran a rock-drill for several hours. N. L. Britton graduated from the Columbia School of Mines, with the degree of engineer of mines, with class of 1879. Presumably he took the mining course because it was the best curriculum in general science that Columbia College then offered. From 1879 to 1887 he was assistant in geology in the School of Mines, becoming instructor on botany in the latter year. Although it is therefore not remarkable that he was competent to run a rock-drill, he was, nevertheless, a man of wide as well as great ability.

THOMAS T. READ,
Vinton Professor of Mining

COLUMBIA UNIVERSITY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

IODINE-POTASSIUM-IODIDE, AS A FIXATIVE AND DIFFERENTIAL STAIN[1]

IODINE-POTASSIUM-IODIDE, prepared according to the usual formula of one gram of iodine crystals, two grams of potassium iodide and 300 cc of water, was found to be useful as a fixative and differential stain in studies on the germination of conidia of the Peronosporales. Its value in this connection was discovered while studying the relation of time and temperature to the rate and percentage of germination of conidia of *Peronospora effusa*. In these studies drops of a suspension of conidia in water were placed on

[1] Contribution No. 192 of the Massachusetts Agricultural Experiment Station.

[1] Presented before the Biology Section of the Virginia Academy of Science, April 23, 1931.

microscope slides which were kept in moist chambers in the various incubators. One slide bearing two drops of the conidial suspension was removed from each incubator at definite intervals and the percentage of germination and length of germ-tubes in each drop noted. Two difficulties were encountered in these studies. First, the continued germination of the conidia and elongation of the germ-tubes after the slides were removed from the incubators resulted in considerable error in the last drops of each group that were examined. Second, the conidia were hyaline and therefore difficult to see. Because of these difficulties an attempt was made to find a means of killing the conidia promptly when they were removed from the incubators and to find a stain that would make them more readily visible. Of the several fungicides and stains tested, iodine-potassium-iodide was found to be the most satisfactory because it served for both purposes and in addition differentiated between the germinated and ungerminated conidia.

In practise, one drop of the iodine-potassium-iodide solution was added to each drop of spores as soon as they were taken from the incubator. This almost instantly killed the conidia and stained the ungerminated ones a golden brown color. The germ-tubes of the recently germinated conidia were also stained golden brown, but the empty spore cases remained colorless. In the more advanced stages of germination the germ-tubes did not stain at all or only at the tip.

The differential property of the stain appears to be due to the fact that it stains only the protoplasm of the conidium and not the conidial or germ-tube wall. The protoplasm of the germinating conidium migrates into the germ-tube and is eventually consumed during its growth. Therefore, the germinated conidia are stained only in the germ-tube or not at all.

Iodine-potassium-iodide was used with equally good results in studying the germination of conidia of *Peronospora parasitica*. It was also used as a stain for fresh conidia of *Peronospora lami* and *Plasmopara gerani* and dried specimens of *Peronospora destructor*, *Bremia lactucae*, *Basidiophora kellermani* and *Albugo candida*.

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BERNICE BRIGGS

VIRGINIA TRUCK EXPERIMENT STATION
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AN IMPROVED METHOD OF DIRECT SMEAR EXAMINATION FOR ACID-FAST BACILLI IN SPUTUMS[1]

THE routine method of examining sputums for acid-fast bacilli by taking a loopful of the sputum from the sputum jar frequently gives negative results when the number of tubercle bacilli in the sputum is comparatively small. Concentration of a fairly large amount of sputum is usually resorted to in such cases in order to obtain a positive result. But this is time-consuming and therefore not practicable where a large number of specimens are examined.

We found in connection with another investigation that by carefully selecting the material and thorough examination of the smears, we were able to obtain the same results on the direct examination of the sputum as after concentration. The method employed was as follows:

DIRECT SMEAR EXAMINATION

The sputum was poured into a petri dish and was examined for mucus flakes. If the sputum was fluid, the flakes were collected by means of a pipette and were expelled on two chemically clean, new slides making fairly thick smears. If the sputum was very mucoid, a heavy wire loop was used instead of a pipette. The smears were allowed to dry in the air and were then stained by a slightly modified Ziehl-Neelsen method, in which the counterstain was 1–1000 dilution of brilliant green instead of methylene blue. Both smears were thoroughly examined for acid-fast bacilli with the aid of a mechanical stage.

When the result was negative on the direct examination, the sputum was concentrated in the following manner.

CONCENTRATION OF SPUTUM

The sputum was pipetted into chemically clean 50 cc centrifuge tubes, which contained glass beads. An equal amount of 3 per cent. NaOH was added, the tube was stoppered with a sterile solid rubber stopper and, after vigorous shaking by hand, it was incubated at 37° C. for from 30 to 45 minutes. The tube was shaken every 5 minutes during incubation to prevent sedimentation. The mixture was then centrifuged at high speed for one hour and the sediment again examined for acid-fast bacilli.

We examined in this manner 369 specimens from 268 suspected and definite cases of tuberculosis, and in each instance the result on the direct smear examination of the unconcentrated sputums was identical with that obtained after concentration. In no instance was a positive result obtained after concentration when it was found negative on the direct smear.

It would therefore seem that by carefully selecting the material and thorough examination of the smears,

[1] From the Bureau of Laboratories, New York City Department of Health, under the direction of Dr. William H. Park.

more positive results may be obtained on routine examination without resorting to concentration of sputums.

LUCY MISHULOW
MILDRED MELMAN
MARIE ROMANO

AN OVER-COMPLEX APPARATUS

THE ingenious device described by J. H. Wales in SCIENCE for June 15 (79: 7059, 545) for obtaining a constant flow of liquid from a vessel by means of a siphon float appears to involve a fallacious complexity. It is inferred that by floating an inner container A, in an outer vessel of liquid, the level of the liquid in A will remain at a nearly constant point because the inner vessel with its contents rises by flotation as the liquid in it is siphoned off. This is scarcely a true picture. As the vessel A rises from loss of contents the level in B falls, and since the level in B always remains at a given height above the level of A the two levels will sink together. Any uniformity the system may have, therefore, is strictly dependent on the level in B, which is lowered in direct proportion to the volume of liquid removed. If the same liquid is used in each vessel, and if cost, restricted quantity or other limitation on the liquid in A need not be considered, where then is the advantage of the inner vessel? Exactly the same result would be attained if the float siphon were placed directly in B and A discarded altogether.

W. A. MCCUBBIN

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SPECIAL ARTICLES

ON A SELECTIVE GAMETOGENIC EFFECT OF CERTAIN HYPOPHYSEAL EXTRACTS

IT has been well established that the structure and function of the testis, both as regards its production of germ cells and of its internal secretion, rapidly degenerate after removal of the anterior hypophysis and that both functions are restored by the administration of implants or extracts of anterior hypophyseal substance. It is of special interest that, depending on their method of preparation, extracts of hypophyseal substance can be made which have relatively much more influence on the germinal than on the internally secreting mechanism of the testis.

The hypophyseal extracts here reported were those employed in another series of experiments for their synergic properties when added in vitro to pregnancy-prolan. By their use it was possible to markedly increase the limited effects of prolan on normal immature females and to bring about the development of the ovary and ovulation in hypophysectomized females. These preparations were forty per cent. alcoholic extracts of desiccated anterior pituitary tissue, or trypsin-erepsin digests of such extracts. They maintained the germinal epithelium of the testis of hypophysectomized rats and, moreover, caused its repair after the profound regression encountered forty days after hypophysectomy, without effect on the internally secreting mechanism as mirrored by infantile seminal vesicles. Indeed, our results, which are to be published in detail elsewhere, show that the testis may increase threefold in weight though the seminal vesicles remain completely atrophic. In contrast to these results, the predominating effect of other gonadotropic preparations, whether from hypophysis, pregnant mares' serum, pregnant human serum, urine or placenta, is on the internally secreting component of the testis—usually considered to be the Leydig tissue.

Entirely independently of these studies, Smith, Engle and Tyndale have recently shown that the substance in menopause urine, like the hypophyseal extracts here reported, differs from the substance in pregnancy urine in its stimulating effect on the germinal rather than on the interstitial testicular tissue, and by the combination of the substance in menopause with that in pregnancy urine Smith and Engle have also secured synergic effects in hypophysectomized females.

The possibility of preparing hypophyseal extracts which effect selectively the seminiferous epithelium, as does the substance in menopause urine, furnishes presumptive evidence of an underlying chemical similarity if not identity of the two substances and of a true hypophyseal origin of the menopause hormone.

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A NEW TYPE OF FEVER AGENT

THE increasing use of artificial fever in various diseased conditions is arousing interest in the production of fever by chemical means. In some cases, such as general paresis and some chronic infections, pyretic drugs owe their possible value to the temperature increase; in other conditions, such as obesity and perhaps psychic apathy, improvement may be ascribed to metabolic stimulation.

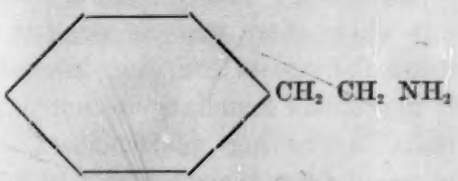
Fever results from metabolic increase under two

conditions only: (1) if the latter is extreme; (2) if the heat-loss mechanism is impaired. Pharmacologists recognize groups of drugs producing fever in either of these two ways.

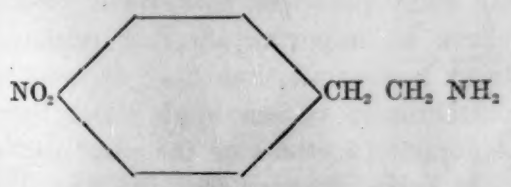
In the first place, the dinitro derivatives of phenol, cresol and naphthol seem to rely almost entirely on excess heat production for the creation of fever; the heat-dissipating measures attempted by the body are no match for the metabolic orgy induced.

On the other hand, sympathetic stimulants (adrenaline, ephedrine and, preeminent in this connection, beta-tetrahydronaphthylamine), while producing fever partly by calorigenic action, act chiefly by their propensities for saving heat. For instance, the blood flow through the body surface is greatly slowed and, as Gilman and I[1] have shown, the vapor pressure of the body decreases, permitting less escape of heat by evaporation of water from the body surfaces.

With the idea of developing a new field of synthetic fever-producing substances which might combine some virtues of each of the two above groups, I sought as a starting point a very simple nitro-aromatic sympathetic stimulant. Phenyl-ethylamine



represents the simplest type of sympathetic agent (Barger and Dale).[2] Eighteen years ago, I[3] showed that this substance will produce a slight fever in dogs. Professor Arthur J. Hill, of the Department of Chemistry, has now kindly made for me a few grams of *p.* nitro-phenylethylamine,



a substance apparently never hitherto tested pharmacologically. This substance was at once found capable of raising the body temperature of guinea-pigs and rabbits by several degrees Fahrenheit within some fifteen to thirty minutes; two rabbits have exhibited as high a temperature as 107° F. with a dose of 120 mgm/K (Fig. 1). The therapeutic range is not wide, for in the guinea-pig, 70 mgm/K is ineffective, while the lethal dose is certainly less than 200 mgm/K.

[1] H. G. Barbour and A. Gilman, *Jour. Pharm. and Exp. Therap.*, 50: 277, 1934.

[2] G. Barger and H. H. Dale, *Jour. Physiol.*, 41: 19, 1910.

[3] H. G. Barbour, *Jour. Pharm. and Exp. Therap.*, 8: 126, 1916.

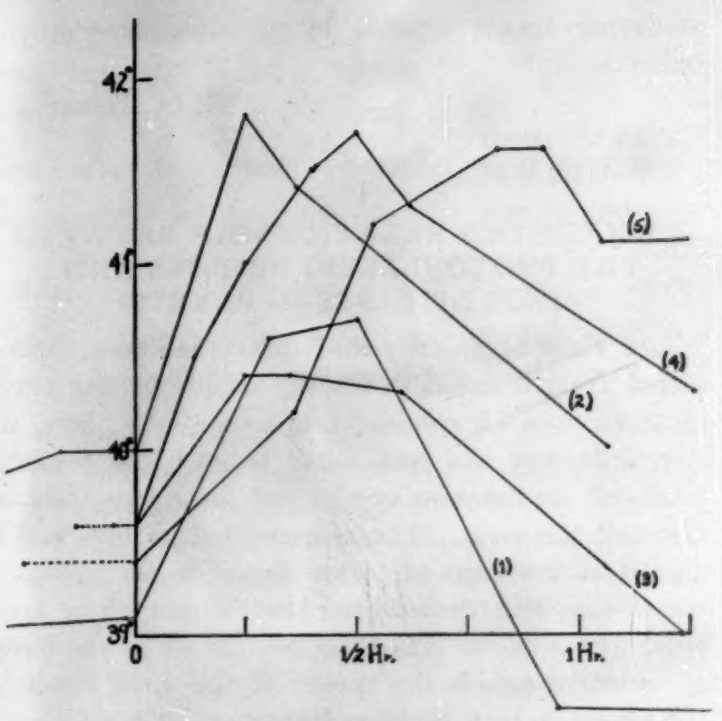


FIG. 1. Fever produced by *p.* nitro-phenylethylamine. Curves 1 and 2, guinea-pigs each given 90 mgm/K subcutaneously. Curve 3, 640 gram rabbit given 100 mgm/K. Curves 4 and 5, rabbits, 3 kilos each, each given 120 mgm/K. *Ordinates:* body temperature in degrees Centigrade; abscissae: time in hours. All injections at zero hour.

Animals given from 90 to 120 mgm/K subcutaneously begin within a very few minutes to show such symptoms as exophthalmos, dilation of the pupils, constriction of the ear vessels and general muscle tremors followed, especially in guinea-pigs, by visible shaking chills. Erection of the fur coat and increases in heart rate and in respiratory rate and depth also occur. The return of body temperature to normal is apparently associated with *complete recovery.*

A high degree of blood concentration is shown by the following determinations made by Dr. Ethel Burack:

Serum specific gravity in a guinea-pig increased from 1.0219 to 1.0251 (14.6 per cent.); in a rabbit, from 1.0243 to 1.0252 (3.7 per cent.). Serum osmotic pressure in a guinea-pig increased from 0.826 to 0.977 (18.3 per cent.); in a rabbit, from 0.860 to 1.041 (21. per cent.).

The whole blood specific gravity of a rabbit (No. 5 in the chart) decreased from 1.0490 in six minutes to 1.0474, but in twenty minutes had risen to 1.0505, and in forty minutes to 1.0528, indicating an increase of 7.8 per cent. All these blood concentration phenomena tend to interfere with the loss of bodily heat. The fever curves of two guinea-pigs and three rabbits are presented in Fig. 1.

Professor Hill and I are outlining a program by which new chemicals are to be synthesized and pharmacologically tested in the promising field of fever-

producing agents typified by *p.* nitro-phenylethylamine.

H. G. BARBOUR

YALE UNIVERSITY
MAY 12, 1934

A SUGGESTED RELATIONSHIP BETWEEN THE PROTOPLASTIC BRIDGES AND VIRUS DISEASES IN PLANTS[1]

THE virus of onion yellow dwarf has been transferred from diseased to healthy onions by the bites of more than 75 species of aphids. Very little, if any, difference has been noted between the feeding habits of the different species and their capacities to transmit the virus. The systemic nature and rapid spread of the virus of yellow dwarf in the growing onion has been demonstrated by means of several species of aphids. After the inoculation by the bites of infective aphids the spread of the virus through the tissues is very rapid and apparently in all directions. In following the course of the stylets of the aphid's beak it was occasionally observed, in the case of intercellular penetration, such as is exemplified by *Myzus persicae* Sulz. and *Aphis rumicis* Linn., that the content of a cell adjacent to the path of the stylets apparently had been partially extracted without the cell walls having been punctured.

In connection with the study of the tracts of the stylets, both intercellularly and intracellularly, through the tissues and the spread and effect of the virus, attention was also given to the protoplasmic bridges or plasmodesms between adjacent cells, with the thought in mind that these structures may function in the spread of the virus from cell to cell and also afford a means by which intercellular feeders are able to make contact with the protoplasm without piercing the cell wall.

In the onion and in all the other plants examined for plasmodesms, including more than a dozen of our common plants that have virus diseases, protoplasmic bridges were found to be prevalent in all the living tissues of the leaves and stems—the study of plasmodesms having been so far confined to these parts. In the onion they were found in the leaves, in the meristematic tissues of the bulb and in the flowering stalk. They were variable in size, ranging from only a very few to 60 or more microns in diameter. They connected the cells usually in all directions. In case of cells with thin walls, as in the meristematic tissues and in the tissues of leaves, the plasmodesms were undivided. They were single strands, whereas in case of cells with thick walls, as in the flowering stalk of the onion, the plasmodesms were usually divided into a number of delicate strands in the region of the middle lamella of the cell wall. In all instances, however, the plasmodesms were visible under the ordinary high-power combinations of the microscope and therefore were ample in size to permit viruses and many other disease-producing agents to pass from cell to cell.

Each wall of a living cell was traversed by a number of plasmodesms. The number and distribution of the plasmodesms radiating in the different directions from a cell varied much according to the shape of the cell. In case of elongated rectangular cells the plasmodesms through the end walls were usually numerous, uniform in size and distribution and small and crowded, whereas those through the lateral walls were relatively few per unit area. The ones traversing the lateral walls varied somewhat in size, ranging from a few to many microns in diameter, and were irregularly distributed. Between irregularly shaped cells, where there is no distinction as to end and lateral walls, the plasmodesms through the different walls were similar in type and distribution. In character and distribution they were similar to those in the lateral walls of the elongated rectangular cells, except that they were more closely spaced. Even through those walls where there was the greatest sparsity of plasmodesms the stylets coursing, intercellularly, the region of the middle lamella could not penetrate very far without contacting plasmodesms unless they abruptly veered from their course. In case the plasmodesms are only incidentally encountered by the aphids during the feeding process these bridges are sufficiently numerous through any of the cell walls to be accessible and serve as a means by which the insect could inoculate the content of cells without having to pierce or rupture the cell walls. It is, therefore, quite plausible that these protoplasmic bridges have an important bearing relative to the intercellular movements, not only of solutions and other substances of various kinds which have to do with the normal functions of the plant, but also of viruses and other disease-producing agents as suggested by Samuel.

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